A STUDY OF THE EFFECTIVENESS OF PHYSIOTHERAPY IN THE MANAGEMENT OF YOUNG CHILDREN WITH MINIMAL CEREBRAL DYSFUNCTION[1]

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Minimal cerebral dysfunction (MCD) is one of many terms used to describe the syndrome exhibited by children who demonstrate mild abnormalities on clinical neurological assessment. The neurological signs of minimal cerebral dysfunction are manifested in the nature of the reflex and automatic sensory responses as well as in the motor responses to specific stimulations. Those reactions which persist beyond the normal age for their integration, together with other mild signs of neurological dysfunction are also symptomatic of minimal cerebral dysfunction.

Other terms for this syndrome commonly encountered include Minimal Brain Damage (MBD), Sensory Integrative Dysfunction and Specific Learning Disability (SLD). The latter term is considered to be an educational diagnosis and its relationship to MCD has been noted by Touwen (1972). His research studies have found that "all infants who present with mild neurological findings do not have learning or behaviour problems later, but the opposite does tend to be true; *i.e.* a high percentage of children with learning and behaviour problems do have neurological findings and a history of pre- or postnatal difficulties. The proportions of boys is much higher than girls."

Some of the emotional, behavioural and social problems of children with MCD or SLD appear to be the result of the child's reaction to his functioning at a lower level of competency than his peers, despite his adequate intelligence. The behaviours develop through the child's attempt to cope with his problem and may be manifested in various ways. For example, the child may exhibit such emotional reactions as aggression, withdrawal, immaturity, irrational fears or excessive fear of failure, while in terms of behaviour he might be hyperactive, hypoactive, defensive or show signs of physical withdrawal. Socially, the child may show that he has poor self-respect, poor social interaction and poor group relations.

The awareness of the existence of children with MCD or SLD by members of professional disciplines is growing rapidly. So too is the awareness of the role which may be played by the developmental physiotherapist in the total team assessment and treatment of such children.

Currently, the Department of Physiotherapy, University of Queensland is involved in a research study designed to evaluate, refine and improve the physiotherapy assessment and treatment procedures used in the management of children with MCD. This paper presents the results of an evaluation of the effectiveness of physiotherapy management programmes, which used a developmental neurological or "sensory integrative" method of treatment, designed to normalise the child's neurological status and his functional developmental abilities.

SUBJECTS

Experimental Group

To be included in the study, children had to meet certain criteria, *viz.:* a normal intelligence range, absence of genetic defects (for example, Down's syndrome), and areas of abnormal functioning as determined by a screening neurodevelopmental assessment. Of the 139 children referred during the period, 108 were assessed as having MCD, 78 of these remaining in the study until its completion.

The withdrawal of subjects was due in part to the reluctance of some parents to be

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involved in a continuing home management programme, and to transfer of families out of the city.

However, relevant facts relating to history and initial assessment were collected for the total group of 108 eligible children.

Questioning of parents and teachers revealed that 34% of the children were considered to have learning problems. However, some of the children were of pre-school age and the children with learning difficulties actually represented 56% of the school age group. Worthy of note is the fact that 95% of the children with specific learning difficulties were male. In terms of percentage of the male and female MCD groups, 58.3% of the male and 33.3% of the female school groups were experiencing learning problems at school.

These figures highlight the ratio of boys to girls presenting with MCD and, in this study the ratio was 4.7 to 1. This is consistent with other general estimates which have been made for this population of children.

One of the features referred to by a number of the parents of children with MCD was the existence of hyperactivity. It was found that 39% of the total MCD population initially assessed (108) either displayed some form of hyperactivity, or were reported to do so in other situations (such as at school). Of these, 76% were male and 24% were female. Considering this incidence in terms of the proportion of boys to girls in the total group, it was found that 36% of the male and 52.6% of the female MCD subgroups were hyperactive. Such figures suggest that although more boys than girls develop MCD, those girls who do so are much more likely to be hyperactive than are the boys with MCD.

While 39% of the MCD population was considered to be hyperactive to some degree, only 21% of the total group was receiving drug therapy (mainly for hyperactivity). Of those children who were found to be hyperactive but not receiving drugs, some had in fact discontinued drug therapy after its failure to produce positive results. These figures support the views of other researchers who have noted a 50% favourable response in children receiving drug therapy for hyperactivity.

Control group

In undertaking an evaluation of the effectiveness of specific forms of treatment, wherever possible a control group of subjects should be used. However, in some cases, such practice is considered to be impractical or unethical and the evaluation must rely on the strength of the trend shown by the statistical analysis. In this particular study, children were referred to the clinic in the hope that effective measures would be taken to reduce the learning, behavioural or clumsiness problems with which the children presented. Believing that in this instance it was unethical to do so, no control group was planned for the study. However, during the course of the project, it was evident that a small "natural" control group was available. This consisted of those children whose parents decided against cooperating in the programme of management after the initial assessment and who did not return during the six month period for progressive assessment and advice. At the end of six months, such parents were asked to bring their children for a further assessment and, as a number agreed to this, results relating to the progress of a small "control" group of 7 children were obtained.

PROCEDURE

The study of each child involved both the collection of appropriate data and the implementation of a suitable programme. Relevant facts relating to developmental history were elicited, and these included family history, perinatal history (referring to both maternal and birth factors), postnatal management (with particular reference to problems in sucking, cuddling and behaviour) and developmental milestones, in addition to problems observed at school.

Each child was given a complete neurodevelopmental assessment during his first visit to the clinic as well as at other appropriate stages of the study. This form of assessment was developed by Burns and Watter (1974) and modified for this population of children by Watter and Bullock (1975). During this assessment, a test of the child's performance was made in the areas of gross motor abilities,

significant signs, visual responses, primitive reflexes, orientation and postural reactions, movement and posture relative to position, the tactile system, the proprioceptive system, the vestibular system and spatial reactions, fears and compensatory actions and in motor abilities.

A rating scale was devised for each test, so that degrees of abnormality in performance could be recorded. Except for four tests (significant signs, nystagmus, early primitive reflexes and body righting reaction), all tests were rated on a 1 to 4 scale. As a general rule, the scores were defined as follows:

1 = normal

2 = mild problem/abnormality

3 = moderate problem/abnormality

4 = severe problem/abnormality.

However, in the tests for significant signs, nystagmus, early primitive reflexes and body righting reactions, there were fewer scores. The meaning of each score for each assessment test was carefully defined (Bullock and Watter, 1977).

On the basis of the neurological assessment, a treatment was designed and a specific home programme explained to the parents, so that daily routines could be instigated. While the frequency of attendance at the clinic depended on the needs of the individual child and family unit, all children were reassessed after three and six months. The same physiotherapist carried out all assessments and provided all treatment programmes. Tests for reliability and repeatability of assessment by the physiotherapist were undertaken on a group of randomly selected children and the results showed a high degree of consistency in all cases.

TREATMENT

The tactile, proprioceptive and vestibular functions are the most basic of the sensory processes, and are the earliest maturing ones. The reflex and postural processes are largely tactile and proprioceptive or vestibular in function and because of this, they are tied to the development of the sensory systems. In addition, there is developmental interplay between reflex and postural processes. For example, persisting reflex patterns delay the acquisition of normal adaptive postural reactions, and alternatively, development of normal postural reactions inhibit (or cause to integrate) the primitive reflexes.

The integrity of these basic systems is important for the normal development of higher or later developing sensory systems (namely, visual, auditory and motor). Consequently, problems in the basic areas tend to produce problems in the higher areas. For example, vestibular, proprioceptive and tactile problems may predispose to visual, auditory and motor problems.

For these reasons, physiotherapists begin treatment at the basic sensory levels (namely, tactile, proprioceptive, vestibular) in an attempt to encourage the normal background for development. In few cases would physiotherapy treatment begin by focusing on the higher cortical functions (visual, auditory and motor).

In the treatment of the children in the study, the therapy was focused at the most basic level of problem for each child. With improvement, the programme was modified to involve the higher levels of functioning more directly. However, during the course of treatment, improvement was often noted in these higher level functions before any specific intervention had begun. It was apparent that as the sensory developmental bases were "normalised", they provided a more normal basis for the development of higher level functions. Active specific intervention could then aid the functional improvements in these areas.

Placement in the "normal" category after a period of treatment indicates that functionally, the children can perform within the normal range of expectations and under normal circumstances. However, in working with these children, it has been noted that in situations of extreme stress or illness, they may show a temporary decline in the level of functioning, which usually disappears when the stress is relieved. Following a course of physiotherapy treatment and a return to a "normal" classification on assessment, an astute observer may be able to identify one of these children in a normal population by virtue of a "poorer quality of movement", although no precise problem may be definable. In the physiotherapist's experi-

ence, the child's residual problem at the conclusion of treatment may be expressed simply in a slower rate of learning new skills.

RESULTS

At the completion of the study, performance details were available for each child as they applied to the initial assessment and progressive assessments after periods of 3 and 6 months of physiotherapy management. The results of these assessments were collated so that the number and percentage of children showing any degree of abnormality in any of the assessment areas could be tabulated for further analysis.

Two forms of data analysis were carried out. In the first, abnormalities in each area were considered collectively, regardless of the scoring level: any score above "1" ("normal") was referred to as an "abnormality", for the purpose of demonstrating incidence of abnormality as a whole. This provided a satisfactory overview of the progress of children during the study period.

The second form of analysis was far more detailed and took into account the child's score in each area of each assessment. By tracing the changes in level of abnormality with time, a much clearer picture of the progress of children with treatment was provided than was possible with the summarised analysis.

Summary analysis

Table 1 presents a summary of the percentage of abnormalities (at any scoring level "2"-"4") which were found to occur in each specific area at each of the three progressive assessments. It can be seen that for every area tested, the percentage of abnormalities decreased markedly over the six month period. This improvement can be seen clearly in Figure 1.

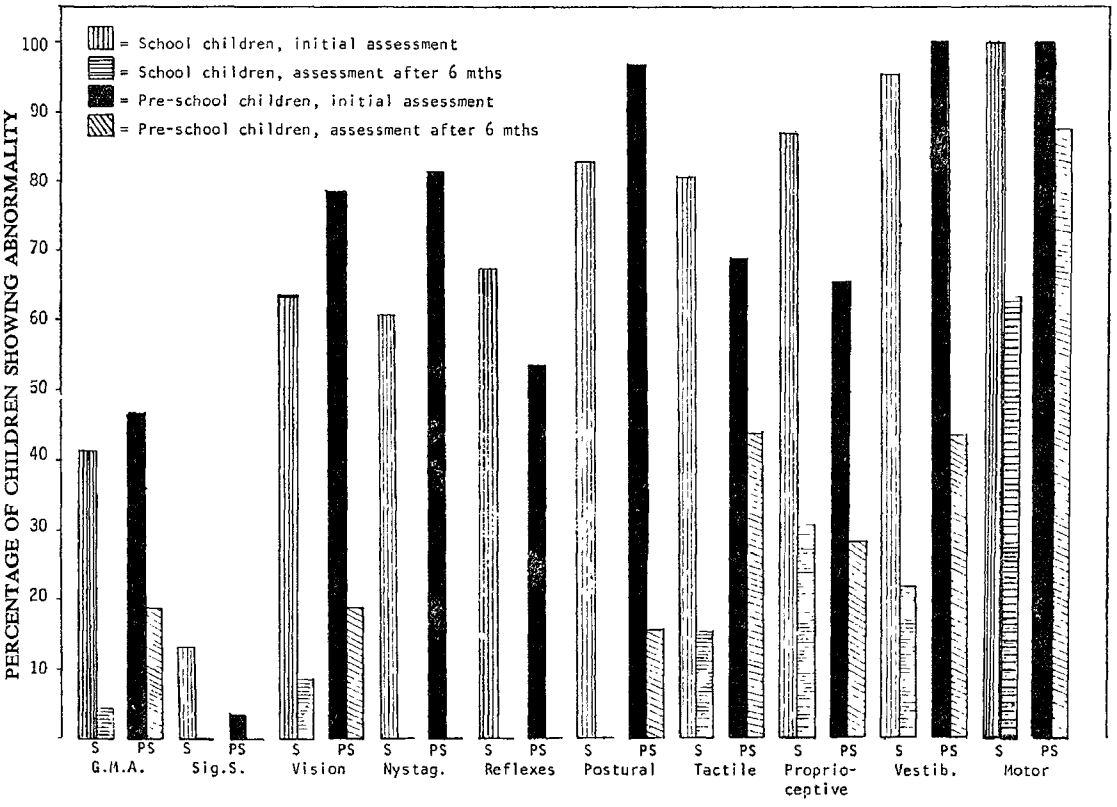

FIGURE 1

Incidence of abnormalities initially and after six months' physiotherapy management.

For the total subject population, the initial incidence of abnormality was more frequent in the more complex and composite tests. For example, while small percentages of children showed abnormalities in initial tests for significant signs and some reflexes, and close to half of the subject population exhibited problems of proprioception and in gross motor abilities, a much larger proportion of children displayed abnormalities of vision, posture and touch. Very large percentages of subjects were shown to have abnormal responses in tests relating to vestibular and spatial reactions and to motor planning. It is significant that of those areas, five of them (postural reactions, tactile function, proprioception, vestibular and space reactions and motor planning) are usually only examined in this functional way by developmental physiotherapists, who are concerned with the relationship between the sensory and motor tests. These five areas are not commonly assessed by paediatricians, who tend to focus their attention on the child's performance in relation to gross motor development and milestones (in which fewer abnormalities are seen to occur, as Table 1 indicates).

TABLE 1

RESPONSE TO PHYSIOTHERAPY MANAGEMENT

Area	Percentage of Abnormalities Present								
	School Age			*Pre-School Age*			*Total Group*		
	Assessment			*Assessment*			*Assessment*		
	Initial	*3 mths.*	*6 mths.*	*Initial*	*3 mths.*	*6 mths.*	*Initial*	*3 mths.*	*6 mths.*
GMA	41.3	17.4	4.4	46.9	31.3	18.8	43.6	23.1	10.3
Sig. Signs	9.0	0	0	3.0	0	0	6.4	0	0
Vision	63.0	39.1	8.7	78.1	56.3	18.8	66.6	46.2	12.8
Nystagmus	65.2	34.8	0	84.4	43.8	0	73.1	38.5	0
REFLEXES									
— Primitive	4.4	0	0	3.1	0	0	3.8	0	0
— Tonic	67.4	13.0	0	50.0	9.4	0	60.3	11.5	0
POSTURE									
— H.R.R.	72.0	21.7	0	81.2	40.6	6.3	75.6	29.5	2.6
— Other	56.5	28.3	0	81.3	43.8	9.4	66.6	34.6	3.8
TOUCH									
— T.F.P.A.	80.4	47.8	13.0	62.5	65.6	40.6	73.1	55.1	24.4
— Other	34.8	6.5	2.2	25.0	9.4	3.1	30.8	7.7	2.6
PROPRIOCEPTION									
— Tone	52.2	8.7	2.2	46.9	15.6	9.4	50.0	11.5	5.1
— Synkinesis	73.9	56.5	33.0	30.7	28.1	25.0	60.3	44.9	29.5
VESTIBULAR AND SPACE									
— Total	95.7	73.9	21.7	100	90.6	43.8	97.4	80.8	30.8
— Vestibular	89.1	34.8	4.4	87.5	59.4	15.6	88.5	44.9	9.0
— Space	93.5	71.7	21.7	93.8	80.6	43.8	93.6	79.5	30.8
MOTOR									
— Total	100	87.0	63.0	100	93.8	87.5	100	89.7	73.1
— Apraxia	84.8	56.5	15.2	87.5	62.5	34.4	85.9	59.0	23.1
— Crossing body midline	76.1	26.1	2.2	81.3	43.8	18.8	78.2	33.3	9.0
— Skills (learn)	100	87.0	61.9	100	93.8	87.5	100	89.7	71.8

Careful examination of Table 1 shows that over 90% of the children demonstrated abnormalities in vestibular and spatial responses and in motor abilities. Although the complete identification of all children with MCD would rely on the use of all assessments listed, in view of the high incidence of abnormalities in those particular areas, it is possible that they could initially be used alone where a rapid screening process of the population was required. Further study of such a possibility would be of value.

In certain areas, the rate of improvement was such that despite a relatively high initial incidence of abnormality, the level was either very low or at zero after six months of treatment. This is particularly obvious in tests for nystagmus, postural reactions, primitive reflexes, vestibular reactions and crossing the body midline. The most marked rate of decrease in percentage of any form of abnormality occurred in responses to tests for vestibular reactions, tonic reflexes, postural reactions, tone, touch and motor planning. Abnormalities of vision were also shown to decrease quite rapidly with the physiotherapy management programme. The rate of improvement in response to tests for gross motor abilities, significant signs, spatial concepts, synkinesis and ability to learn skills was less marked. Areas in which there remained a considerable percentage of abnormality even after six months of treatment included tests for ability to learn motor skills, synkinesis, spatial concepts and tactile finger position agnosia.

A comparison of the progress of the experimental and control groups revealed that while there was a decrease of 86% and 75% in the total number of abnormalities exhibited by the School and pre-School children respectively, after six months of treatment, during the same period, there was an increase of 7% and 14% in the untreated groups of similar age. Figure 2 illustrates the difference in progress between the experimental and control groups. While the number of subjects in the control group was small, this comparison does serve to indicate the trend towards an increase in problems over time as opposed to the improvement demonstrated by children in the experimental group.

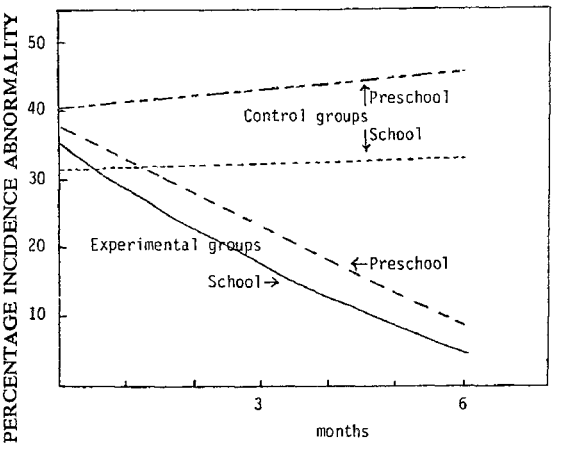

FIGURE 2

Comparison of progress in experimental and control groups.

Because it was considered that both the incidence of abnormalities and the rate of progress might differ between pre-school and school age children, the performance of the two groups was analysed separately. Examination of Table 1 demonstrates that in fact there is very little difference between the two groups.

While the incidence and degree of abnormality are not identical in the two groups, in most assessment areas, the percentages of subjects initially occurring in each abnormality score is markedly similar. Those areas in which school age children showed a higher percentage of abnormalities on initial assessment included significant signs, tonic reflexes, touch and proprioception, while pre-school children demonstrated a higher incidence of abnormality in areas relating to gross motor ability, vision and postural response. However, comparison of the progressive changes in the percentage incidence over time shows a similarity in rate and degree of improvement of the two groups in all areas. Figure 3 illustrates both the nature of the changes and the similarity in performances of the two groups of children.

To determine whether any correlation exists between age and initial incidence of abnormalities, a regression analysis was carried out. The line of regression is presented in Figure 4. Its slope, together with the correlation co-efficient of —.16 demonstrates

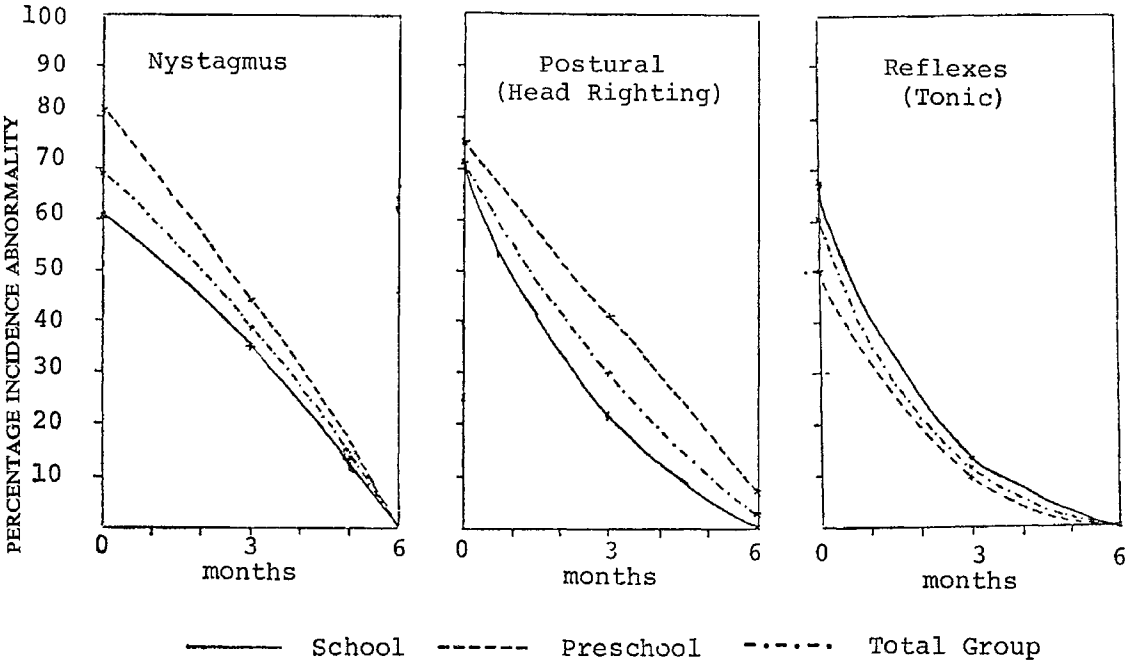

FIGURE 3

Incidence of abnormalities initially and after physiotherapy management.

that in fact, age is not a significant factor in regard to incidence of the neurological problems assessed by physiotherapists in children with minimal cerebral dysfunction. However, in view of the fact that the existence of problems revealed by neurological assessment in children attending school can contribute to and be associated with the development of emotional, social, behaviour and learning problems, the importance of early referral for treatment must be recognised. Nothing is gained by delaying treatment of these children, but it is evident that, where the nature of the problem is not recognised until after school age, a course of physiotherapy management will cause it to modify in a relatively short space of time.

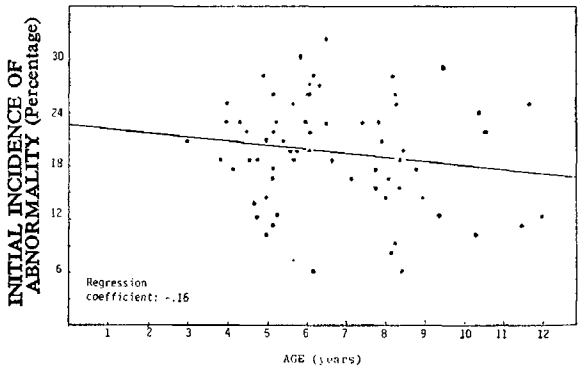

FIGURE 4

Relationship of age to initial incidence of abnormality.

Detailed analysis

Table 2 presents the percentages of children whose performances at each of the tests were graded as 1, 2, 3 or 4. With few exceptions, all levels of abnormality were initially found to exist in the children. However, in most cases, only small percentages of the total subgroups were shown to have severe abnormality (as revealed by a score of "4"). Notable exceptions to this finding, were the results for tests of head righting reaction (both optical and vestibular), synkinesis, tactile finger position agnosia and visual and verbal copy ability, where large percentages of children showed marked abnormalities in response to testing. For the greatest proportion of tests, the highest percentage of children performed initially at a scoring level of "3" (moderate degree of abnormality).

Not only the incidence, but also the level of abnormality after six months of treatment is demonstrated in Table 2. The remarkable progress which occurred in all areas can be seen by comparing the percentage of children in each scoring level initially and after six months of treatment.

Only in the tests for synkinesis, head righting and tactile finger position agnosia did any children remain at the "4" score after

TABLE 2

PERCENTAGE OF CHILDREN IN EACH SCORING GRADE AT INITIAL (a) AND FINAL (b) ASSESSMENT

Area	Score							
	1		*2*		*3*		*4*	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
1. Gross Motor Ability	56.4	89.7	23.0	10.3	16.7	0	3.8	0
2. Significant Signs	93.6	100	6.4	0	0	0	0	0
3. Nystagmus	26.9	100	10.3	0	62.8	0	0	0
4. Strabismus	91.0	96.2	6.4	3.8	2.6	0	0	0
5. Fixation	42.3	85.9	25.6	12.8	26.9	1.3	5.1	0
6. Follow—L.	37.2	88.5	20.5	10.3	35.9	1.2	6.4	0
7. Follow—R.	34.6	87.2	20.5	11.5	38.5	1.3	6.4	0
8. Follow—Both	33.3	89.7	24.4	9.0	34.6	1.3	7.7	0
9. Convergence	39.7	89.7	25.6	9.0	30.8	1.3	3.8	0
10. Primitive Reflexes	100	100	0	0	0	0	0	0
11. Extensor Thrust	100	100	0	0	0	0	0	0
12. TLR	70.5	100	23.1	0	6.4	0	0	0
13. ATNR	45.6	100	35.9	0	16.7	0	3.8	0
14. STNR	48.7	100	29.5	0	16.7	0	5.1	0
15. Placing	83.3	100	14.1	0	2.6	0	0	0
16. Landau	100	100	0	0	0	0	0	0
17. Head Righting	24.4	97.4	23.1	0	21.8	2.6	30.8	0
18. Body on Body Righting	89.7	100	2.6	0	7.7	0	0	0
19. Protection	41.0	94.9	17.9	5.1	16.7	0	1.3	0
20. Equilibrium	25.6	93.6	15.4	6.4	42.3	0	3.8	0
21. Reaction to Touch	70.5	97.4	14.1	2.6	7.7	0	7.7	0
22. Reaction to Pain	98.7	100	0	0	1.3	0	0	0
23. Avoidance	98.3	100	1.3	0	0	0	0	0
24. Tactile Finger Position Agnosia	11.5	74.3	6.4	11.6	11.5	10.3	55.1	1.2
25. Astereognosis	89.7	100	3.8	0	6.1	0	1.2	0
26. Level of Body Awareness	89.5	100	6.4	0	0	0	0	0
27. Muscle Tone	53.8	97.4	20.5	1.3	17.9	1.3	7.7	0
28. Static Holding	20.5	88.5	19.2	11.5	57.7	0	2.6	0
29. Synkinesis	39.7	70.5	6.4	7.7	7.7	14.1	46.2	7.7
30. Awareness of Limb Position	84.6	98.7	6.4	1.3	9.0	0	0	0
31. Head Righting (without vision)	12.8	9.1	15.4	6.4	20.5	0	51.3	2.6
32. Spatial Concepts	12.8	70.5	75.6	26.9	9.0	2.6	2.6	0
33. Fears	61.5	98.7	23.1	1.3	14.1	0	1.3	0
34. Compensatory Actions	32.1	96.1	42.3	3.9	25.6	0	0	0
35. Visual Copy	12.8	80.8	15.4	19.2	24.4	0	47.4	0
36. Verbal Copy	50.0	93.5	11.5	6.5	16.7	0	21.8	0
37. Fine Motor Apraxia	98.7	98.7	0	1.3	1.3	0	0	0
38. Dominance	96.2	98.7	1.3	1.3	2.6	0	0	0
39. Crossing the Body Midline	21.8	91.0	20.5	9.0	53.8	0	3.8	0
40. Rapid Alternating Movement	41.0	84.6	24.4	14.1	28.2	1.3	6.4	0
41. Motor Skills	1.3	42.3	16.7	51.3	76.9	6.4	5.1	0
42. Learning Motor Skills	0	28.2	7.7	53.8	79.5	18.0	12.8	0

six months. (7.7%, 2.6% and 1.2% respectively.) Similarly, it can be seen that despite the initial high incidence of "3" scores, after six months, only in a relatively few tests were a small percentage of "3" scores allocated.

Table 2 illustrates that where abnormalities still existed after six months of physiotherapy management, for the most part they did so only in the "mildly abnormal" score of "2". Even so, the percentages of children at this level were relatively small in comparison with those at initial assessment.

Figure 5 is illustrative of the changes in the percentage of subjects in each of the scores over the six month period. Although there were minor variations in slopes of these graphs for each assessment, the nature of the changes between score lines was similar in each case. It can be seen that while the "3" and the "4" score lines slope towards zero, the "1" score line rises rapidly. The direction of the "2" score line shows an intermediate rise as the previously high scores of "3" and "4" move to "2" and a final slope towards zero as a high percentage of subjects return to normal.

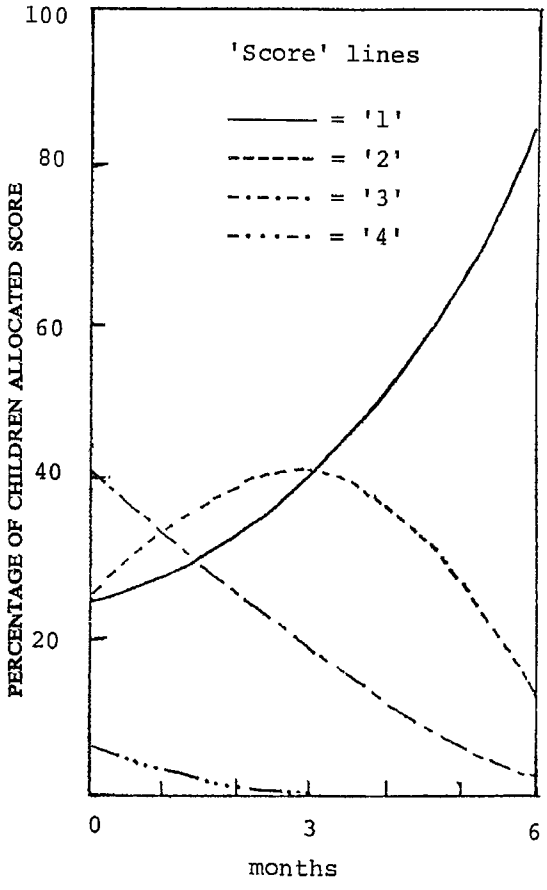

FIGURE 5

Changes in percentage of subjects at each grading score over six months' treatment period.

CONCLUSIONS

In an evaluative study of the effectiveness of physiotherapy programmes for the treatment of children with minimal cerebral dysfunction, 78 children were assessed and treated for a minimum of six months. Detailed analysis provided overwhelming evidence of the progress made by the children during that period. While all children did not reach a score of "1" ("normal") in all assessment areas by that time, the small proportions who finally scored "2", "3" or "4" were such as to demonstrate the significance in improvement of the total subject sample. With such marked trends in progress evident from the data, it could be anticipated with some degree of certainty that, given an additional period of treatment, a return to normality on assessment would occur for a great majority, if not all, of the subjects.

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